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(54) Title of the invention Method of manufacturing lightweight calcium silicate product
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Detailed description

1. Title of the invention

Method of manufacturing lightweight calcium silicate product

2. Claims

The method of manufacturing lightweight calcium silicate products to provide a lightweight calcium silicate articles produced by molding a specific shape out of raw material containing 0 - 50 weight % of slag, 0 - 50 weight % of gypsum, 5 - 80 weight % of cement and/or slaked lime, 2 - 30 weight % of fiber, 0 - 20 weight % of solid particles composed of alkali-soluble silicon oxide and 5 - 90 weight % of hollow particles composed of the alkali-soluble silicon oxide.

3. Detailed description of the invention

[Applicable field in industry]

This invention relates to the method of manufacturing a lightweight cement product, in particular, of a lightweight product with sophisticated design to improve the flexural strength and shrinkage using hollow silicon oxide material.

[Conventional technology]

Conventionally the use of pearlite and styrene beads were suggested for ceramic building materials

for the purpose of weight reduction in Pat. Pub. S 48-25718 and Pat. Pub. S47-35061. However, those materials are not strong enough because they do not have the alkali reactivity and they function only as the lightweight aggregate.

[Problem that the invention will solve]
The purpose of this invention is to solve the abovementioned disadvantages of the conventional technology and to provide the method of manufacturing lightweight calcium silicate in order to produce articles with excellent workability in designing and improved flexural strength and shrink properties.

[Means to solve the problem]
This invention aims to solve the abovementioned problems and provides the method of manufacturing lightweight calcium silicate products to provide lightweight calcium silicate articles produced by specifically molding a specific shape out of the raw material containing 0 - 50 weight % of slag, 0 - 50 weight % of gypsum, 5 - 80 weight % of cement and/or slaked lime, 2 - 30 weight % of fiber, 0 - 20 weight % of solid particles composed of alkali-soluble silicon oxide and 5 - 90 weight % of hollow particles composed of the alkali-soluble silicon oxide.

In this invention, the slag contained in the raw material has the following advantage although it is not an essential ingredient: The reaction of Al_2O_2 in the slag facilitates the formation of tobermorite and improves the flexural strength and resistance to freezing and thawing. However, the content should not preferably exceed 50 weight % because H_2S and other toxic gases arise excessively in the autoclave. More preferable value of slag content should be 30 - 50 weight %.

Gypsum has the following advantage although it is not an essential ingredient. It improves the plasticity of the material and reduces chipping and other defects. However, if the content of gypsum exceeds 50 weight %, the following undesirable conditions occur: Intermediate products such as ettringite and mono-sulfate are formed and it becomes difficult for tobermorite to be formed even in the end product. More preferable value of gypsum content should be 2 - 10 weight %.

In this invention, cement and slaked lime function as follows: $Ca(OH)_2$ formed in the hydration reaction of cement or slaked lime $Ca(OH)_2$ causes hydrothermal reaction with SiO_2 and generates C-S-H and tobermorite. These C-S-H and tobermorite are excellent in durability and flexural strength. If the content of the cement and/or slaked lime is less than 5 weight %, the abovementioned effect of the additives is small, and if it exceeds 80 weight %, then it is not desirable because of the following reason: If the content is 5 weight % or less, most of SiO_2 remains unreacted and the flexural strength becomes low. On the other hand, if it exceeds 80 weight %, most of $Ca(OH)_2$ remains unreacted and the material becomes more vulnerable to carbonation caused by CO_2, which reduces the durability. The contents of the cement and/or slaked lime should preferably be between 40 and 60

weight %, within the abovementioned potential range. Applicable types of cement would include Portland cement, alumina cement, sulfate-resisting cement, blast furnace cement, pozzolan cement, out of which, Portland cement and alumina cement are desirable because they contain less $CaSO_4$, and they are not likely to generate intermediate products of ettringite or mono-sulfate and are ready to form tobermorite easily.

Fibers are effective in increasing the strength of the product. The content of fibers should not preferably be less than 2 weight % because that effect becomes low. It should not preferably exceed 30 weight % because the surface property would deteriorates and, if it happens to become worse, cracks may arise. More preferable value of fiber content should be 5 - 10 weight %, within the abovementioned range.

Solid particles composed of alkali-soluble silicon oxide have the following advantage when contained although it is not an essential ingredient: When typical SiO_2 particles are used, the reaction ratio is limited to 30 - 50%. On the other hand, when hollow particles are used, the reaction ratio increases and the amount of unreacted SiO_2 reduces. This also enables weight reduction. However, if the solid particle content exceeds 20 weight %, an undesirable condition occurs as: The solubility of the solid particles in the boiling water at 100°C should preferably be 100 ppm or higher. Specific examples of these would include silica fume, diatom earth, white clay and silica sand.

In this invention, hollow particles composed of alkali-soluble silicon oxide not only form air bubbles in concrete but they also elute and penetrate into the concrete to increase the concrete strength. The elution of some hollow particles into concrete during the hardening process would be sufficient, but the elution of all particles would be more preferable. The desirable size of the hollow particles should be within the range of 50 - 500 μm. Particles smaller than this range are not desirable because the bulk specific gravity becomes higher, which makes it difficult to reduce the weight. Particles larger than this range are not desirable because a significant floatation phenomenon appears at the time of dehydrating press, and those particles deform or collapse at the time of pressure forming. Desirable thickness of hollow particles should be 1 - 5 μm. If the content of the hollow particles is less than 5 weight %, hardening caused by the additives is not much and weight reduction is not sufficient and flexural strength is low therefore not desirable, while if it exceeds 90 weight %, the flexural strength becomes lower therefore not desirable. More preferable content is within 20 - 80 weight %, in particular, within the range of 30 - 50 weight %. Examples of applicable hollow particles would include shirasu (or sirasu) balloons, silica balloons and glass balloons.

For molding process, materials are blended in the specified proportion and slurried with added water. Then, this slurry is molded into a specific shape using dehydrating press molding, extrusion molding or other process. To evenly disperse hollow particles, extrusion molding should preferably be adopted. To float hollow particles on the surface, however, to ensure specifically sophisticated

design, dehydrating press molding should preferably adopted.

[Embodiment]

Slurry with the composition shown in Table 1 was prepared by blending materials. Then, 1% of methylcellulose was added and a calcium silicate plate was prepared by extrusion molding. The flexural strength, Young's modulus, bulk specific gravity and dimensional change ratio of the calcium silicate plate were measured. The results are recorded in the same table. A comparative example is also included in the table.

The table reveals that the results of this invention have greater flexural strength, smaller dimensional change and smaller bulk specific gravity. The dimensional change is measured according to JIS A-5422.

[Effects of the Invention]

The current invention provides effective improvement in flexural strength, expansion and shrinkage and resistance against freezing and thawing. What is more, the invention has the effect of weight reduction by using solid alkali-soluble silicon oxide. For dehydrating molding, the unique texture of particles can be exposed visible on the surface of the product by floating the hollow particles of low bulk specific gravity.

Attorney Tsugamura Toshiro and one other

Table 1

	Embodiment	1	2	3	4	5	6	7	8	9	10	Comparative example
Composition (weight %)	Blast furnace slag	10	10	10		10	10	10	10			10
	Cement	30	30	30	30	30	40	40	40			40
	Slaked lime									40	40	23
	Silica sand	10	10	10	10	10						10
	Silica fume	4	4	4	14	4	4	4	4	14	14	14
	Shirasu balloon	40	40	40	40		40	40	40	40		0
	Silica balloon					40					40	0
	Bulb (NBKP)	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
	Alkali-resistant glass fiber	0.5			0.5	0.5	0.5			0.5	0.5	0.5
	Polypropylene fiber		0.5					0.5				1
	Acrylic fiber			0.5					0.5			
Properties	Flexural strength (kg/cm^2)	100	97	103	115	92	110	111	107	105	100	88
	Young's modulus ($10^4 kg\ f/cm^2$)	4.99	4.80	5.01	4.86	4.68	5.09	5.11	5.14	5.05	5.01	4.41
	Bulk specific gravity	0.854	0.850	0.851	0.860	0.851	0.861	0.859	0.863	0.851	0.849	0.852
	Dimensional change (%)	0.113	0.122	0.114	0.092	0.139	0.133	0.137	0.132	0.178	0.182	0.2

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審査請求　未請求　請求項の数 1　（全4頁）

⑭発明の名称　軽量ケイ酸カルシウム製品の製造方法

㉑特　願　平1-8713
㉒出　願　平1(1989)1月19日

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明　細　書

1．発明の名称

軽量ケイ酸カルシウム製品の製造方法

2．特許請求の範囲

1．スラグ0～50重量%，石膏0～50重量%，セメント及び／又は消石灰5～80重量%，繊維2～30重量%，アルカリに可溶な珪素の酸化物からなる中実粒子0～20重量%，アルカリに可溶な珪素の酸化物からなる中空粒子5～90重量%を含有する原料を所定形状に成形し、軽量ケイ酸カルシウム製品を得る軽量ケイ酸カルシウム製品の製造方法。

3．発明の詳細な説明

［産業上の利用分野］

本発明は、軽量セメント製品の製造方法、特に、中空の珪素酸化物を用いて軽量かつ高意匠で、曲げ強度と収縮を向上せしめた製品の製造方法に係るものである。

［従来の技術］

従来、窯業系建材において、軽量化を目的として、パーライトやスチレンビーズを使用することが特開昭 48-25718、特開昭 47-35061 により提案されている。しかしこれらの材料はアルカリに対して反応性がなく、軽量骨材としての機能しか有しておらず、強度の点で不十分であった。

［発明の解決しようとする問題点］

本発明の目的は、従来技術が有していた前述の欠点を解消しようとするもので、意匠性に優れ、曲げ強度及び収縮性の向上した製品の得られる軽量ケイ酸カルシウムの製造方法を提供するものである。

［問題点を解決するための手段］

本発明は、前述の問題点を解決すべくなされたものであり、スラグ0～50重量%，石膏0～50重量%，セメント及び／又は消石灰5～80重量%，繊維2～30重量%，アルカリに可溶な珪素の酸化物からなる中実粒子0～20重量%，ア

ルカリに可溶な珪素の酸化物からなる中空粒子５～90重量%を含有する原料を所定形状に成形し、軽量ケイ酸カルシウム製品を得る軽量ケイ酸カルシウム製品の製造方法を提供するものである。

本発明において、原料中のスラグは必須成分ではないが含有することにより次のような利点がある。スラグ中の Al_2O_3分の反応によりトバモライトの生成が容易になり，曲げ強度の向上，耐凍結融解が向上する。しかしながら、その含有量が50重量%を越えるとオートクレーブ中において H_2S等有毒ガスの発生が著しくなるので好ましくない。より好ましいスラグの含有量は30～50重量%である。

石膏は、必須成分ではないが含有することにより次の利点がある。材料の可塑性が向上し欠け等が少なくなる。しかしながら、かかる石膏の含有量が50重量%を越えると次のような点で好ましくない。中間生成物であるエトリンガイト，モノナルフェイトが生成し、最終生成物であるトバモライトが生成しにくくなる。より好ましい石膏の含有量は２～10重量%である。

本発明において、セメント，消石灰は次のような作用がある。セメントの水和反応において生成する $Ca(OH)_2$或いは消石灰 $Ca(OH)_2$とSiO_2との間で水熱反応し、C-S-H 及びトバモライトを生成する。これら C-S-H，トバモライトは耐久性，曲げ強度に優れている。セメント及び／又は消石灰の含有量が５重量%未満では添加による上記効果が少なく，80重量%を越えると次のような点で好ましくない。５重量%以下では未反応の SiO_2分が多量に残り、曲げ強度が低い。一方，80重量%を越えると、未反応の $Ca(OH)_2$が多量に残り，CO_2ガスによる材料の炭酸化をより受けやすくなり，耐久性が低下する。セメント及び／又は消石灰の含有量は上記範囲中40～60重量%の範囲がより好ましい。かかるセメントとしてはポルトランドセメント，アルミナセメント，耐硫酸塩セメント，高炉セメント，ポゾランセメントが例示されるが、この内、ポルトランドセメント，アルミナセメントは次の点で好ましい。$CaSO_4$分が少なく、中間生成物であるエトリンガイド，モノナルフェイトを生成しにくく、トバモライトの生成が容易である。

繊維は製品強度を増大させる効果がある。繊維の含有量は２重量%未満ではその効果が少ないので好ましくなく、30重量%を越えると次の点で好ましくない。表面性状が悪化し、さらに著しくなるとクラックが生じる。繊維の含有量は上記範囲中５～10重量%の範囲がより好ましい。

アルカリに可溶な珪素の酸化物から中実粒子は必須成分ではないが含有することにより次のような利点がある。通常の SiO_2粒子を用いた場合、その反応率は30～50%程度にとどまるのに対し、中空粒子を用いた場合、反応率が向上し、未反応の SiO_2が低減する。また、計量化が可能になる。しかしながら、中実粒子の含有量が20重量%を越えると次の点で好ましくない。かかる中実粒子は 100℃の沸とう水に対し溶解度が 100 ppm 以上であるものが好ましい。具体的にはシリカゲル，シリカフューム，珪藻土，白土，硅砂が例示される。

本発明においてアルカリに可溶な珪素の酸化物からなる中空粒子はコンクリート内に気泡を形成する作用をすると共に溶出してコンクリート中に侵入しその強度を増大する作用をする。かかる中空粒子は、硬化の過程でコンクリート中に少なくとも一部が溶出するものであればよいが、その全体が溶出するものがより好ましい。中空粒子の大きさは50～500 μm の範囲が好ましく、上記範囲より小さいものは、かさ比重が高くなり，軽量化が困難になるので好ましくなく、上記範囲より大きいものは脱水プレス時の浮遊現象が著しくなる。或いは、加圧成形時に粒子が変形，潰れるので好ましくない。また、中空粒子の肉厚は１～５ μm の範囲が好ましい。中空粒子の含有量は５重量%未満では添加による効果が少なく軽量化が不充分であると

共に、曲げ強度が低いので好ましくなく、90重量%を越えると曲げ強度が低下するので好ましくない。より望ましくは20～80重量%であり、30～50重量%の範囲が特に望ましい。かかる中空粒子としては、シラスバルーン，シリカバルーン，ガラスバルーンが例示される。

成形に当っては、各原料を所定の割合に調合し、水を添加してスラリー化する。次いでこのスラリーを脱水プレス成形，押出成形などで所定形状に成形する。中空粒子を均一に分散する場合は押出成形を採用することが好ましく、中空粒子を表層に浮遊し意匠性を発現する場合は、脱水プレス成形を採用することが好ましい。

［実施例］

各原料を調合して表1に示す組成のスラリーを得た。次いで、これにメチルセルロースを1%添加し、押出成形し板状のケイ酸カルシウムを得た。次いでこのケイ酸カルシウム板について曲げ強度，ヤング率，かさ比重，寸法変化率を測定し、その結果を同表に併記した。なお同表には比較例も併記した。

同表より明らかなように本発明によるものは曲げ強度が大きく、寸法変化率が小さく、かさ比重が小さい。なお、寸法変化率はJIS A-5422に準じて測定した。

表 1

	実施例	1	2	3	4	5	6	7	8	9	10	比較例
組成（重量%）	高炉スラグ	10	10	10		10	10	10	10			10
	セメント	30	30	30	30	30	40	40	40			40
	消石灰									40	40	23
	珪砂	10	10	10	10	10						10
	シリカフューム	4	4	4	14	4	4	4	4	14	14	14
	シラスバルーン	40	40	40	40		40	40	40	40		0
	シリカバルーン					40					40	0
	パルプ（ＮＢＫＰ）	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
	耐アルカリガラス繊維	0.5			0.5	0.5	0.5			0.5	0.5	0.5
	ポリプロピレン繊維		0.5					0.5				1
	アクリル繊維			0.5					0.5			
特性	曲げ強度 （kgf／cm²）	100	97	103	115	92	110	107	111	105	100	88
	ヤング率 （10^4 kgf／cm²）	4.99	4.80	5.01	4.86	4.68	5.09	5.11	5.14	5.05	5.01	4.41
	かさ比重	0.854	0.850	0.851	0.860	0.851	0.861	0.859	0.863	0.851	0.849	0.852
	寸法変化率 （%）	0.113	0.122	0.114	0.092	0.139	0.133	0.137	0.132	0.178	0.182	0.2

〔発明の効果〕

本発明は、曲げ強度，膨張収縮，耐凍結融解性に優れた効果を有し、特に、アルカリに可溶な中空の珪素の酸化物を使用することにより軽量化という効果も認められる。さらに、脱水成形の場合にはかさ比重の低い中空粒子を浮遊させることにより、粒子自身のもつ意匠を製品の表面に付与できる。

代理人 粟野重孝 外1名

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AN 114:87565 CA
ED Entered STN: 09 Mar 1991
TI Manufacture of lightweight calcium silicate products
IN Yada, Akira; Shirakawa, Tetsuro
PA Asahi Glass Co., Ltd., Japan
SO Jpn. Kokai Tokkyo Koho, 4 pp.
CODEN: JKXXAF
DT Patent
LA Japanese
IC ICM C04B028-18
CC 58-3 (Cement, Concrete, and Related Building Materials)
FAN.CNT 1

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PRAI	JP 1989-8713		19890119		

CLASS

PATENT NO.	CLASS	PATENT FAMILY CLASSIFICATION CODES
JP 02192447	ICM	C04B028-18

AB A mixture containing slag 0-50, **gypsum** 0-50, **cement** and/or $Ca(OH)_2$ 5-80, fiber 2-30, alkali soluble dense SiO_2 particle 0-20, and alkali soluble hollow SiO_2 particle 5-90 weight% is shaped and hardened to give the title product with high bending strength and low shrinkage. Thus, a mixture comprising blast-furnace slag 10, **cement** 30, silica sand 10, silica fume 4, shirasu balloon (bloated **volcanic ash**) 40, pulp 5.5, and alkali-resistant glass fiber 0.5 part with addition of methylcellulose 1 part was extruded and cured to give a board having bending strength 100 kg/cm2, Young's modulus 4.99 + 104 kg/cm2, bulk d. 0.854 and linear shrinkage 0.113%.
ST lightwt calcium silicate **concrete** silica
IT Shirasu (soil)
RL: USES (Uses)
(balloon, **cement** boards containing, lightwt., for improved bending strength and low shrinkage)
IT Mortar
(calcium silicate, lightwt., containing alkali soluble hollow silica particle, with high bending strength and low shrinkage)
IT Acrylic fibers, uses and miscellaneous
Polypropene fibers, uses and miscellaneous
RL: USES (Uses)
(**cement** boards containing, lightwt.)

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(74) Attorney Patent lawyer: Tsugamura Toshiro and one other

Detailed description

1. Title of the invention

Method of manufacturing lightweight calcium silicate product

2. Claims

The method of manufacturing lightweight calcium silicate products to provide a lightweight calcium silicate articles produced by molding a specific shape out of raw material containing 0 - 50 weight % of slag, 0 - 50 weight % of gypsum, 5 - 80 weight % of cement and/or slaked lime, 2 - 30 weight % of fiber, 0 - 20 weight % of solid particles composed of alkali-soluble silicon oxide and 5 - 90 weight % of hollow particles composed of the alkali-soluble silicon oxide.

3. Detailed description of the invention

[Applicable field in industry]

This invention relates to the method of manufacturing a lightweight cement product, in particular, of a lightweight product with sophisticated design to improve the flexural strength and shrinkage using hollow silicon oxide material.

[Conventional technology]

Conventionally the use of pearlite and styrene beads were suggested for ceramic building materials

for the purpose of weight reduction in Pat. Pub. S 48-25718 and Pat. Pub. S47-35061. However, those materials are not strong enough because they do not have the alkali reactivity and they function only as the lightweight aggregate.

[Problem that the invention will solve]

The purpose of this invention is to solve the abovementioned disadvantages of the conventional technology and to provide the method of manufacturing lightweight calcium silicate in order to produce articles with excellent workability in designing and improved flexural strength and shrink properties.

[Means to solve the problem]

This invention aims to solve the abovementioned problems and provides the method of manufacturing lightweight calcium silicate products to provide lightweight calcium silicate articles produced by specifically molding a specific shape out of the raw material containing 0 - 50 weight % of slag, 0 - 50 weight % of gypsum, 5 - 80 weight % of cement and/or slaked lime, 2 - 30 weight % of fiber, 0 - 20 weight % of solid particles composed of alkali-soluble silicon oxide and 5 - 90 weight % of hollow particles composed of the alkali-soluble silicon oxide.

In this invention, the slag contained in the raw material has the following advantage although it is not an essential ingredient: The reaction of Al_2O_2 in the slag facilitates the formation of tobermorite and improves the flexural strength and resistance to freezing and thawing. However, the content should not preferably exceed 50 weight % because H_2S and other toxic gases arise excessively in the autoclave. More preferable value of slag content should be 30 - 50 weight %.

Gypsum has the following advantage although it is not an essential ingredient. It improves the plasticity of the material and reduces chipping and other defects. However, if the content of gypsum exceeds 50 weight %, the following undesirable conditions occur: Intermediate products such as ettringite and mono-sulfate are formed and it becomes difficult for tobermorite to be formed even in the end product. More preferable value of gypsum content should be 2 - 10 weight %.

In this invention, cement and slaked lime function as follows: $Ca(OH)_2$ formed in the hydration reaction of cement or slaked lime $Ca(OH)_2$ causes hydrothermal reaction with SiO_2 and generates C-S-H and tobermorite. These C-S-H and tobermorite are excellent in durability and flexural strength. If the content of the cement and/or slaked lime is less than 5 weight %, the abovementioned effect of the additives is small, and if it exceeds 80 weight %, then it is not desirable because of the following reason: If the content is 5 weight % or less, most of SiO_2 remains unreacted and the flexural strength becomes low. On the other hand, if it exceeds 80 weight %, most of $Ca(OH)_2$ remains unreacted and the material becomes more vulnerable to carbonation caused by CO_2, which reduces the durability. The contents of the cement and/or slaked lime should preferably be between 40 and 60

weight %, within the abovementioned potential range. Applicable types of cement would include Portland cement, alumina cement, sulfate-resisting cement, blast furnace cement, pozzolan cement, out of which, Portland cement and alumina cement are desirable because they contain less $CaSO_4$, and they are not likely to generate intermediate products of ettringite or mono-sulfate and are ready to form tobermorite easily.

Fibers are effective in increasing the strength of the product. The content of fibers should not preferably be less than 2 weight % because that effect becomes low. It should not preferably exceed 30 weight % because the surface property would deteriorates and, if it happens to become worse, cracks may arise. More preferable value of fiber content should be 5 - 10 weight %, within the abovementioned range.

Solid particles composed of alkali-soluble silicon oxide have the following advantage when contained although it is not an essential ingredient: When typical SiO_2 particles are used, the reaction ratio is limited to 30 - 50%. On the other hand, when hollow particles are used, the reaction ratio increases and the amount of unreacted SiO_2 reduces. This also enables weight reduction. However, if the solid particle content exceeds 20 weight %, an undesirable condition occurs as: The solubility of the solid particles in the boiling water at 100°C should preferably be 100 ppm or higher. Specific examples of these ~~would include~~ silica fume, diatom earth, white clay and silica sand.

In this invention, hollow particles composed of alkali-soluble silicon oxide not only form air bubbles in concrete but they ~~also elute and~~ penetrate into the concrete to increase the concrete strength. The elution of some hollow particles into concrete during the hardening process would be sufficient, but the elution of all particles would be more preferable. The desirable size of the hollow particles should be within the range of 50 - 500 μm. Particles smaller than this range are not desirable because the bulk specific gravity becomes higher, which makes it difficult to reduce the weight. Particles larger than this range are not desirable because a significant floatation phenomenon appears at the time of dehydrating press, and those particles deform or collapse at the time of pressure forming. Desirable thickness of hollow particles should be 1 - 5 μm. If the content of the hollow particles is less than 5 weight %, hardening caused by the additives is not much and weight reduction is not sufficient and flexural strength is low therefore not desirable, while if it exceeds 90 weight %, the flexural strength becomes lower therefore not desirable. More preferable content is within 20 - 80 weight %, in particular, within the range of 30 - 50 weight %. Examples of applicable hollow particles would include shirasu (or sirasu) balloons, silica balloons and glass balloons.

For molding process, materials are blended in the specified proportion and slurried with added water. Then, this slurry is molded into a specific shape using dehydrating press molding, extrusion molding or other process. To evenly disperse hollow particles, extrusion molding should preferably be adopted. To float hollow particles on the surface, however, to ensure specifically sophisticated

design, dehydrating press molding should preferably adopted.

[Embodiment]

Slurry with the composition shown in Table 1 was prepared by blending materials. Then, 1% of methylcellulose was added and a calcium silicate plate was prepared by extrusion molding. The flexural strength, Young's modulus, bulk specific gravity and dimensional change ratio of the calcium silicate plate were measured. The results are recorded in the same table. A comparative example is also included in the table.

The table reveals that the results of this invention have greater flexural strength, smaller dimensional change and smaller bulk specific gravity. The dimensional change is measured according to JIS A-5422.

[Effects of the Invention]

The current invention provides effective improvement in flexural strength, expansion and shrinkage and resistance against freezing and thawing. What is more, the invention has the effect of weight reduction by using solid alkali-soluble silicon oxide. For dehydrating molding, the unique texture of particles can be exposed visible on the surface of the product by floating the hollow particles of low bulk specific gravity.

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Table 1

	Embodiment	1	2	3	4	5	6	7	8	9	10	Comparative example
Composition (weight %)	Blast furnace slag	10	10	10		10	10	10	10			10
	Cement	30	30	30	30	30	40	40	40			40
	Slaked lime									40	40	23
	Silica sand	10	10	10	10	10						10
	Silica fume	4	4	4	14	4	4	4	4	14	14	14
	Shirasu balloon	40	40	40	40		40	40	40	40		0
	Silica balloon					40					40	0
	Bulb (NBKP)	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
	Alkali-resistant glass fiber	0.5			0.5	0.5	0.5			0.5	0.5	0.5
	Polypropylene fiber		0.5					0.5				1
	Acrylic fiber			0.5					0.5			
Properties	Flexural strength (kg/cm^2)	100	97	103	115	92	110	111	107	105	100	88
	Young's modulus ($10^4 kg f/cm^2$)	4.99	4.80	5.01	4.86	4.68	5.09	5.11	5.14	5.05	5.01	4.41
	Bulk specific gravity	0.854	0.850	0.851	0.860	0.851	0.861	0.859	0.863	0.851	0.849	0.852
	Dimensional change (%)	0.113	0.122	0.114	0.092	0.139	0.133	0.137	0.132	0.178	0.182	0.2